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Pearl Millet Diseases

A Compilation of Information on the Known Pathogens of Pearl Millet

Pennisetum glaucum (L.) R. Br.

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Abstract

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Cultivation of pearl millet [*Pennisetum glaucum* (L.) R.Br.] for grain and forage is expanding into nontraditional areas in temperate and developed countries, where production constraints from diseases assume greater importance. The crop is host to numerous diseases caused by bacteria, fungi, viruses, nematodes, and parasitic plants. Symptoms, pathogen and disease characteristics, host range, geographic distribution, nomenclature discrepancies, and the likelihood of seed transmission for the pathogens are summarized. This bulletin provides useful information to plant pathologists, plant breeders, extension agents, and regulatory agencies for research, diagnosis, and policy making.

Keywords: bacterial, diseases, foliar, fungal, grain, nematode, panicle, parasitic plant, pearl millet, *Pennisetum glaucum,* preharvest, seedling, stalk, viral.

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Introduction

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] has traditionally been an important grain, forage, and stover crop primarily in the arid and subtropical regions of many developing countries. As pearl millet cultivation expands into nontraditional areas in temperate and developed countries, production constraints from diseases are assuming greater importance. Dissemination of accurate information on diseases of the crop has not kept pace with the increased interest in pearl millet as a viable crop in nontraditional areas.

The literature concerning pearl millet diseases is often confused and contradictory. Many treatises on pathology are composed of information on diseases of "millet," which is a broad category of any number of small-seeded grasses. Millets include pearl millet *(Pennisetum glaucum);* proso, browntop, or broomcorn millet *(Panicum miliaceum);* little millet *(P. sumatrense);* foxtail millet *(Setaria italica);* finger millet or ragi *(Eleusine coracana);* teff *(Eragrostis tef);* fonio (*Digitaria* spp.); guinea millet *(Brachiaria deflexa);* barnyard or japanese millet *(Echinochloa crus-galli);* jungle rice millet *(E. colonum);* kodo millet *(Paspalum scrobiculatum);* and Job's tears *(Coix lacryma-jobi).* Many diseases of the different millets are quite host-specific, particularly those caused by obligate parasites. Compounding the difficulty of identifying diseases of pearl millet, it is not unusual for a pathogen to be attributed as the cause of a disease on *"Pennisetum"* without a specific host designation. Considerable diversity exists within the genus *Pennisetum,* which consists of over 100 species having chromosomes numbers in multiples of x=5, 7, 8, or 9 (Oliver 1934).

In addition, pearl millet itself has undergone several changes in nomenclature, which can also lead to some confusion. Throughout the literature it is variously referred to as *P. glaucum, P. typhoides, P. americanum,* or other names depending on the accepted nomenclature at the time. It is also known by several different common names including cumbu, bajra, and cattail millet. Because of all these variables, attempts to identify the diseases of "millet" without strict differentiation of the host have resulted in sometimes confused and misinformed quarantine and regulatory policies. This bulletin was written in an attempt to provide some scientific clarity for use in making policy decisions.

Most of the following information was derived from the published scientific literature. When possible, I examined the original publications rather than relying on conclusions and information attributed to earlier scientists by others in more recent publications. Because of the purpose of this document, descriptions of pathogen characteristics and the diseases they cause are necessarily brief. For positive identification of pathogens, reference to the appropriate citations is advised. Designated host ranges can be inconsistent among pathogens. Cross-inoculation studies have not been performed with most of these pathogens, and host specificity and strain specificity are difficult to determine from the literature. Common names of additional hosts were sometimes used instead of binomial nomenclature, and some binomial nomenclature has been changed since publication of the original works. Geographic distributions may vary depending on whether the pathogen has been observed on pearl millet or on other hosts. The accuracy of the geographic distribution on all hosts depends on the degree of host-pathogen specificity, which, as addressed above, is not well defined for most of these pathogens. For the most part, information on seed transmission of diseases does not exist. Seed infection is well documented for several pathogens; however, transmission to the seedling has not often been demonstrated. Despite these problems, some important attributes of known pathogens can be summarized (table 1).

Various regulatory agencies have been concerned about some diseases that are not well documented in the literature. These putative pathogens and their actual role in causing diseases of pearl millet are sometimes vague

Table 1. A quick reference to the infectious diseases of pearl millet

Disease	Pathogen	Attributes*
Bacterial diseases		
Bacterial spot	*Pseudomonas syringae* van Hall	1, 2
Bacterial leaf streak	*Xanthomonas campestris* (Pammel) Dowson pv. *pennamericanum*	
Bacterial leaf stripe	*Pseudomonas avenae* Manns	1
Unnamed bacterial disease	*Pantoea agglomerans* (Ewing & Fife)	
Fungal diseases		
Bipolaris leaf spot	*Bipolaris setariae* (Saw.) Shoem	1, 2
Cercospora leaf spot	*Cercospora penniseti* (Chupp)	2
Curvularia leaf spot	*Curvularia penniseti* (Mitra) Boedijn	1, 2
Dactuliophora leaf spot	*Dactuliophora elongata* Leakey	
Downy mildew	*Sclerospora graminicola* (Sacc.) Schroet.	
	Plasmopara penniseti Kenneth & Kranz.	
Drechslera leaf spot	*Drechslera dematioidea* (Bubak & Wroblewski) Subram. & Jain	1, 2
Ergot	*Claviceps fusiformis* Loveless	1
	Claviceps africana Frederickson, Mantle & de Milliano	1
Exserohilum leaf blight	*Exserohilum rostratum* (Drechs.) K.J. Leonard & E.G. Suggs	1, 2
False mildew	*Beniowskia sphaeroidea* (Kalchbr. & Cke.) Mason	
Head mold	Various fungi	1, 2
Myrothecium leaf spot	*Myrothecium roridum* Tode ex Fr.	1
Phyllachora leaf spot	*Phyllachora penniseti* Syd.	
Phyllosticta leaf blight	*Phyllosticta penicillariae* Speg.	1, 2
Pyricularia leaf spot	*Pyricularia grisea* (Cke.) Sacc	1, 2
Rhizoctonia blight	*Rhizoctonia solani* Kühn	2
	Rhizoctonia zeae Voorhees	2
Rust	*Puccinia substriata* Ell. & Barth. var. *indica* Ramachar & Cumm.	2
Seedling blight	Various fungi	1, 2
Smut	*Moesziomyces penicillariae* (Bref.) Vanky	1, 2
Southern blight	*Sclerotium rolfsii* Sacc.	2
Top rot	*Fusarium moniliforme* Sheldon	1, 2
Zonate leaf spot	*Gloeocercospora sorghi* Bain & Edgerton	1, 2
Viral diseases		
Black-streaked dwarf virus		
Guineagrass mosaic virus		
Indian peanut clump virus		1
Maize dwarf mosaic virus		
Maize streak virus		
Panicum mosaic virus		2
Satellite panicum mosaic virus		2
Wheat streak mosaic virus		2

Table 1. A quick reference to the infectious diseases of pearl millet

Disease	Pathogen	Attributes*
Nematode diseases		
Burrowing nematode	*Radopholos similis* (Cobb) Thorne	
Cyst nematode	*Heterodera gambiensis* Merny & Netscher	
Dagger nematode	*Xiphinema americanum* Cobb	2
Lance nematode	*Hoplolaimus indicus* Sher	
Panagrolaimus nematode	*Panagrolaimus* spp.	1
Ring nematode	*Criconemella ornata* (Raski) Luc & Raski	2
Root-knot nematode	*Meloidogyne incognita* (Kofoid & White) Chitwood	2
	Meloidogyne javonica (Treub.) Chitwood	2
	Meloidogyne arenaria (Neal) Chitwood	2
Root-lesion nematode	*Pratylenchus mulchandi* Nandakumar & Khera	2
	Pratylenchus brachyurus (Godfrey) Filipjev & Sch. Stekh.	2
	Pratylenchus zeae Graham	2
Sting nematode	*Belonolaimus longicaudatus* Rau	2
Stubby-root nematode	*Paratrichodorus minor* (Colbran) Siddiqi	2
Stunt nematode	*Tylenchorhynchus vulgaris* Upadhyay	
	Tylenchorhynchus phaseoli Sethi & Swarup	
	Tylenchorhynchus zeae Sethi & Swarup	
Parasitic flowering plants		
Witchweed	*Striga hermonthica* Benth.	
	Striga asiatica (L.) Kuntze	

* 1, potentially seedborne; 2, endemic to United States on pearl millet.

but are discussed in an attempt to address these concerns where questions of thoroughness may arise.

Bacterial Diseases

Bacterial Spot

Pseudomonas syringae van Hall

Symptoms: Round, oblong, linear, or irregular water-soaked leaf spots expand to form oval to elongate, tan necrotic lesions with a thin, dark-brown margin (Jensen et al. 1991).

Pathogen and disease characteristics: Colonies in culture are grayish white in reflected light and slightly greenish fluorescent in transmitted light. The short, cylindrical rods have 1 to 4 polar flagella at one pole. No spores, aerobic, gram negative. Temperature for growth ranges from 0 to 35 °C, with optimum temperatures between 25 and 30 °C. Resistant to freezing in water.

Host range: Pearl millet, napiergrass, sorghum, sudangrass, johnsongrass, foxtail (*Chaetochloa lutescens* old nomenclature, now *Setaria glaucum*), maize.

Geographic distribution: USA (Iowa); Australia (New South Wales 1964).

Nomenclature discrepancies: *Alternative disease name:* Holcus spot.

Seed transmission: Unknown for pearl millet, but this pathogen has been transmitted by seed in napiergrass (Richardson 1979). It is susceptible to desiccation on glass but is resistant on sorghum seed.

Primary citation: Kendrick 1926.

Bacterial Leaf Streak

Xanthomonas campestris (Pammel) Dowson pv. *pennamericanum*

Symptoms: Symptoms are not clearly defined in the literature but are apparently similar to those of bacterial leaf stripe and streak of sorghum.

Pathogen and disease characteristics: Yellow, mucoid bacterial colonies in culture. Aerobic, motile, gram-negative, rod-shaped bacteria differing pathologically, serologically, and by membrane protein patterns from other pathovars of *X. campestris.* Cells measure 0.45× 2.25 μm and have one polar flagellum. Optimal growth occurs between 26 and 30 °C.

Host range: Pearl millet and proso millet *(Panicum miliaceum).*

Geographic distribution: Nigeria. Also collected from Senegal and Niger (L. Claflin, personal communication, 1995).

Nomenclature discrepancies: None.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Qhobela and Claflin 1988.

Bacterial Leaf Stripe

Pseudomonas avenae Manns

Symptoms: Water-soaking occurs at the ends of advancing interveinal lesions, which vary in length from several centimeters to more than 25 cm. Older lesions are usually light brown.

Pathogen and disease characteristics: The bacteria produce acid when grown on arabinose, fructose, galactose, glucose, glycerol, and sorbitol. Most isolates utilize citrate and grow at 41 °C.

Host range: Pearl millet, maize, sorghum, sugarcane in primary citation. Additional hosts cited are barley, wheat, oats, italian millet, barnyard millet *(Panicum crus-galli* var. *frumentaceum),* proso millet, foxtail millet, finger millet, rice, rye, and vaseygrass *(Paspalum urvillei).*

Geographic distribution: Nigeria.

Nomenclature discrepancies: None.

Seed transmission: Not known to be transmitted through seed in pearl millet, but *P. avenae* has been demonstrated to be seedborne in rice and vaseygrass.

Primary citation: Claflin et al. 1989.

Unnamed Bacterial Disease

Pantoea agglomerans (Ewing & Fife)

Symptoms: Straw-colored lesions with a chlorotic edge, often extending the length of the leaf. Water-soaking occurs at leaf tips and margins in seedlings.

Pathogen and disease characteristics: Bacteria are gram negative, nonfluorescent, fermentative, and rod shaped. They form yellow colonies on nutrient agar.

Host range: Pearl millet.

Geographic distribution: Zimbabwe, possibly India.

Nomenclature discrepancies: The disease may be the same as bacterial leaf streak or bacterial leaf blotch, reported as being caused by *Xanthomonas pennisiti* (Rajagopalan and Rangaswami 1958), *Xanthomonas annamalaiensis* (Rangaswami et al. 1961a), or *Xanthomonas rubrisorghi* (Rangaswami et al. 1961b). See bacterial leaf streak/bacterial leaf blotch in "Questionable or poorly described diseases of pearl millet reported in the literature," p. 30.

Synonym: Erwinia herbicola.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Frederickson et al. 1997.

Fungal Diseases

Bipolaris Leaf Spot

Bipolaris setariae (Saw.) Shoem

Symptoms: Foliar symptoms vary as brown flecks, fine linear streaks, small oval spots, large irregular oval, oblong, or almost rectangular spots measuring 1–10 × 0.5–3 mm. Large fusiform lesions are sometimes produced. Lesions may expand and coalesce. Lesions may be solid dark brown but usually become tan or greyish brown with a more or less distinct dark-brown border (Luttrell 1954).

Pathogen and disease characteristics: Pigmented conidia are fusoid to obclavate fusoid, straight to usually slightly curved, thin walled but becoming moderately thick walled at maturity, pale or moderately dark olivaceous brown, and 44–151 × 10.6–19.6 μm, with 4 to 13 septa (Luttrell 1954).

The pathogen causes seed decay, seedling blight, leaf spot, and head mold of pearl millet. Young plants and maturing plants are most susceptible to foliar blight (Wells and Burton 1967). Seedling blight is more pronounced at temperatures of 25 °C and less (Wells 1967).

Host range: Pearl millet, napiergrass, browntop millet (*Panicum fasciculatum* Swartz) [sic], *Arundinella nepalensis* (Bhowmik 1972), sugarcane, teosinte, maize (Nishihara 1966), sorghum, *Paspalum scrobiculatum, Panicum miliaceum,* barley *(Hordeum vulgare),* wheat *(Triticum aestivum),* oats *(Avena sativa),* cogongrass *(Imperata arundinacea,* old nomenclature, now *I. cylindrica),* bermudagrass *(Cynodon dactylon)* (Misra et al. 1974).

Geographic distribution: Continental United States, Hawaii (Raabe et al. 1981), India, Japan (Nishihara 1966), Zimbabwe, Zambia (Singh et al. 1990).

Nomenclature discrepancies: *Synonyms or similar pathogens:* Several *"Helminthosporium"* species differ only slightly in the thickness of conidial walls and size of the conidia (Luttrell 1954, Luttrell et al. 1974). Some confusion and possible controversy exists in regards to description, taxonomy, and host range of this and other potentially very similar fungi, including:

Bipolaris urochloae (Putterill) Shoem (Singh et al. 1990) [has been implicated in causing "brown leaf spot"]

Drechslera setariae Saw.

Helminthosporium australiense Bugnicourt (Chand and Singh 1966)

Helminthosporium sacchari (van Breda de Haan) Butl. (Misra et al. 1974)

Helminthosporium setariae Saw.

Helminthosporium stenospilum

See table 2 for additional *Bipolaris* species pathogenic to *Pennisetum.*

Seed transmission: Can be isolated from seed (Wells and Winstead 1965, Wilson et al. 1993) and transmitted to seedlings from seeds (Shetty et al. 1982).

Primary citations: As indicated above.

Cercospora Leaf Spot

Cercospora penniseti (Chupp)

Symptoms: Foliar lesions are typically oval, 1–8 × 0.8–2.5 mm, with dark brown margins and pale tan to grey or white centers and dotted with rows of black conidiophore tufts. Lesions can form on stems.

Pathogen and disease characteristics: Conidiophores arise in clusters from small, brown, substomatal stromata. The hyaline, multiseptate conidia are almost filiform (approximately 91–136 × 4 μm), widest in the basal cell or in the first 2 to 3 cells.

Host range: Pearl millet.

Geographic distribution: India (Narayanaswami and Veerraju 1970), United States, possibly Malawi (Wiehe 1953), possibly Tanzania (Mbwaga et al. 1993).

Nomenclature discrepancies: *Synonyms or similar pathogens:*

Cercospora fusimaculans Atk (Wiehe 1953,

Table 2. Host ranges and geographic distributions of *Bipolaris* species pathogenic to *Pennisetum* species*

Species	Host range	Geographic distribution
B. australiensis†	*Chloris, Cymbopogon, Cynodon, Hordeum, Oryza, Pennisetum, Saccharum, Sorghum, Zea*	Australia, Egypt, India, Iraq, Japan, Kenya, Libya, New Zealand, Pakistan, South Africa, Sri Lanka, Sudan, Zimbabwe
B. bicolor†	*Andropogon, Apluda, Brachiaria, Cymbopogon, Eleusine, Eragrostis, Melanocenchris, Oryza, Panicum, Paspalum, Pennisetum, Setaria, Sorghum, Triticum, Urochloa, Zea, Zizania*	Australia, Brazil, Canada, East & West Africa, Ethiopia, India, Ivory Coast, Malaysia, New Zealand, Nigeria, Papua New Guinea, Swaziland, Taiwan, Tanzania, Yugoslavia, USA, Zimbabwe
B. cynodontis†	*Agropyron, Axonopus, Cynodon, Dactyloctenium, Hordeum, Oryza, Panicum, Pennisetum, Triticum, Zea*	Australia, Bangladesh, Brunei, Egypt, Ghana, Guinea, India, Israel, Iraq, Italy, Japan, Kenya, Malaysia, New Zealand, Pakistan, Papua New Guinea, Spain, South Africa, Sudan, Tanzania, Trinidad, Venezuela, Yugoslavia, USA, former USSR, Zimbabwe
B. hawaiiensis†	*Andropogon, Avena, Cenchrus, Chloris, Cynodon, Desmostachya, Digitaria, Eleusine, Hordeum, Oryza, Pennisetum, Saccharum, Setaria, Sorghum, Triticum, Zea*	Australia, Burma, Cuba, Ethiopia, Egypt, India, New Zealand, Pakistan, Sri Lanka, Tanzania, USA (Hawaii), Zambia
B. nodulosa†	*Digitaria, Eleusine, Eragrostis, Pennisetum*	Australia, Brazil, Brunei, Ethiopia, India, Kenya, Malaysia, Malawi, Mauritius, New Zealand, Nigeria, Pakistan, Papua New Guinea, Philippines, Sierra Leone, South Africa, Sri Lanka, Sudan, Taiwan, Tanzania, Uganda, USA, Zambia, Zimbabwe
B. setariae†	*Echinochloa, Eleusine, Eragrostis, Panicum, Pennisetum, Setaria*	Australia, Europe, North America, Ethiopia, India, Sierra Leone, Taiwan, Uganda, Venezuela
B. spicifera†	*Agrostis, Avena, Cymbopogon, Cynodon, Dactylis, Desmostachya, Eleusine, Holcus, Hordeum, Oryza, Panicum, Pennisetum, Phleum, Poa, Saccharum, Sorghum, Triticum, Zea*	Africa, America, Asia, Australia & Oceania, West Indies
B. colocasiae	*Cymbopogon, Colocasia, Pennisetum, Triticum/Hordeum*	India

Table 2. Host ranges and geographic distributions of *Bipolaris* species pathogenic to *Pennisetum* species*

Species	Host range	Geographic distribution
B. indica	*Panicum, Pennisetum, Portulaca*	Australia, China, Egypt, India, South Africa
B. mediocris	*Pennisetum*	Ethiopia, Guinea, South Africa
B. papendorfii	*Pennisetum, Setaria, Sorghum, Triticum*	Australia, Egypt, India, Malawi, Nigeria, Pakistan, South Africa, Sudan, Zimbabwe
B. sacchari	*Cynodon, Panicum, Pennisetum, Saccharum*	Africa, America, Asia, Australasia and Oceania, Europe (Italy)
B. urochloae	*Panicum, Pennisetum, Triticum, Urochloa, Zea*	Australia, Ethiopia, India, Pakistan, South Africa, West Germany, Zimbabwe
B. zeae	*Alloteropsis, Cenchrus, Imperata, Pennisetum, Triticum, Zea*	Australia, Brazil, India

* Information derived from Sivanesan (1987); used with permission of CAB International. Not all *Pennisetum* hosts are *P. glaucum.*

† Known to have a *Cochliobolus* teleomorph.

Alagianagalingam et al. 1971)

Cercospora sorghi Ellis & Everhart (Mbwaga et al. 1993)

Cercospora typhoides (Sharma and Jain 1967)

Phaeoramularia fusimaculans

Seed transmission: Not known to be transmitted by seed.

Primary citations: Luttrell 1954, Rachie and Majmudar 1980.

Curvularia Leaf Spot

Curvularia penniseti (Mitra) Boedijn

Symptoms: Small yellow-brown spots on leaves expand to oblong lesions. Centers of lesions change to brown and margins remain yellow. Lesions are more common on leaf margins.

Pathogen and disease characteristics: Conidia are 29–42 × 13–20 μm at broadest part, triseptate, clavate, and almost always slightly curved at the third cell from the base, which is larger than the others. Cell at each end are subhyaline or pale, intermediate cells are brown, third cell from the base is usually more pigmented and darker.

Host range: *Oryza, Pennisetum, Sorghum, Triticum.* Isolated from *Allium, Dolichos,* and *Richardia.*

Geographic distribution: Australia, India, Indonesia, Malawi, Nepal, Nigeria, Pakistan, continental United States, Hawaii (*C. lunata,* Raabe et al. 1981), Zimbabwe.

Nomenclature discrepancies: *Synonyms or similar pathogens:*

Acrothecium penniseti Mitra

Other species of *Curvularia* can be isolated from pearl millet, including:

Curvularia geniculata (Tracy & Earle) Boed.

Curvularia lunata (Wakker) Boed. [A toxin produced by this pathogen is related to host and cultivar specificity (Gour et al. 1992).]

No information is available to indicate if symptoms caused by other species of *Curvularia* differ from symptoms caused by *C. penniseti.*

See table 3 for additional *Curvularia* species pathogenic to *Pennisetum.*

Seed transmission: *Curvularia* species are frequently isolated from seed.

Primary citations: Luttrell 1954, Sivanesan 1990a.

Dactuliophora Leaf Spot

Dactuliophora elongata Leakey

Symptoms: Symptoms begin on the upper leaf surface as pinpoint isolated brown lesions. As the lesions increase in size, they become brownish at the edge and dirty white or straw colored toward the center. In wet weather, irregular water-soaked areas develop around the spots and turn necrotic. Well-developed lesions have no definite shape or are roughly oval or semicircular, zonate with kidney-shaped patches of necrotic tissue and brown or yellow tissue in between. Black sclerotia develop in upper surface of necrotic tissue.

Pathogen and disease characteristics: Tan aerial mycelium without sclerotia develops on potato dextrose agar. On the host, the white mycelium is appressed to the cuticle on the lower leaf surfaces. Obclavate-ellipsoid to pyriform, brown sclerotia develop on erumpent, cup-shaped sclerotiophores. Sclerotia germinate by producing germ tubes over the entire surface after 4 to 8 hours.

Host range: Pearl millet.

Geographic distribution: Nigeria (Tyagi 1985), Mali, Niger (Wilson et al., in press.).

Nomenclature discrepancies: Disease symptoms illustrated in Williams et al. (1978) and attributed to zonate leaf spot *(Gloeocercospora sorghi)* are probably those of dactuliophora leaf spot.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Tyagi 1985.

Downy Mildew

Sclerospora graminicola (Sacc.) Schroet.

Symptoms: Symptoms often vary as a result of systemic infection. Leaf symptoms begin as chlorosis at the base, and successively higher leaves show progressively greater chlorosis. Infected chlorotic leaf areas can support abundant white asexual sporulation on the lower leaf surface. Severely infected plants are generally stunted and do not produce panicles. Green ear symptoms result from transformation of floral parts into leafy structures.

Pathogen and disease characteristics: Asexual sporangia are produced during the night under moderate temperatures and high humidity. Optimum sporangium production occurs at 20 °C. No sporulation below 70 percent relative humidity. Sporangia germinate to liberate 1 to 12 zoospores, which encyst and germinate by germtube. Sporangia generally do not remain viable very long after daybreak. Sexual oospores are thick-walled, spherical, brownish yellow, and 22 to 35 μm in diameter. Oospores form in colonized plant tissue and can survive from 8 months to 13 years under laboratory conditions.

Host range: Pearl millet. Host specificity is important in determing host range for this pathogen. *S. graminicola* has been reported from maize, sorghum, *Echinochloa crus-galli, Panicum miliaceum, Pennisetum leonis, P. spicatum, Setaria italica, S. lutescens, S. verticillata, S. viridis, S. magna, Euchlaena maxicana,* and *Agrostis alba.* Cross-inoculation studies to different hosts have usually been unsuccessful when attempted.

Geographic distribution: On page 2 of the primary citation, a reference to a 1884 publication by Farlow indicates that *S. graminicola* has been identified in the United States on "other millets." On page 3, the continental U.S. is

Table 3. Host ranges and geographic distributions of *Curvularia* species pathogenic to *Pennisetum* species*

Species	Host range	Geographic distribution
C. eragrostidis†	*Cymbopogon, Digitaria, Eragrostis, Oryza, Panicum, Pennisetum, Rottboellia, Saccharum, Sorghum, Sporobolus, Triticum, Zea*	Australia, Brunei, Burma, Cuba, Fiji, Ghana, Guinea, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Nigeria, Papua New Guinea, Sierra Leone, Solomon Islands, Sri Lanka, Trinidad, USA, Zaire
C. geniculata†	*Axonopus, Cymbopogon, Ischaemum, Oryza, Panicum, Paspalum, Pennisetum, Poa, Saccharum, Sorghum, Sporobolus, Themeda, Triticum, Zea*	Australia, Bangladesh, Bhutan, Bolivia, Brunei, Burma, Canada, Cuba, Dominican Republic, Fiji, Ghana, Guinea, Hong Kong, India, Jamaica, Malawi, Malaysia, Nepal, Nigeria, Pakistan, Papua New Guinea, Peru, Philippines, Seychelles, Sierra Leone, Singapore, Solomon Islands, Sri Lanka, Sudan, Tanzania, Trinidad, Tonga, Uganda, Zaire
C. intermedia†	*Cynodon, Digitaria, Oryza, Pennisetum, Saccharum, Sorghum, Triticum, Zea*	Australia, Brunei, Guinea, Guyana, Hong Kong, India, Malawi, Papua New Guinea, Tanzania, USA, Venezuela, Zimbabwe
C. pallescens†	*Axonopus, Brachiaria, Coix, Cymbopogon, Cynodon, Dactyloctenium, Digitaria, Echinochloa, Euchlaena, Imperata, Oryza, Panicum, Paspalum, Pennisetum, Rottboellia, Saccharum, Setaria, Sorghum, Sporobolus, Triticum, Zea*	Australia, Barbados, Brunei, Burma, Canada, Cuba, Ghana, Hong Kong, India, Indonesia, Jamaica, Kenya, Malawi, Malaysia, Nepal, Nigeria, Pakistan, Papua New Guinea, Peru, Sierra Leone, Singapore, Solomon Islands, Sri Lanka, Sudan, Tanzania, Venezuela, Zimbabwe
C. tuberculata†	*Oryza, Pennisetum, Saccharum, Triticum*	Egypt, France, Indochina, India, Iraq, Pakistan, Sri Lanka, Tanzania, USA
C. verruculosa†	*Buchloe, Chloris, Oryza, Paspalum, Pennisetum, Sorghum, Triticum, Typha, Zea*	Australia, Burma, Egypt, India, Indonesia, Israel, Jamaica, Japan, Malaysia, New Caledonia, Nigeria, Pakistan, Peru, Tanzania
C. lunata	*Cynodon, Oryza, Pennisetum, Saccharum, Sorghum, Triticum, Zea*	Australia, Brazil, Cameroon, Columbia, Ecuador, Fiji, Gambia, Guadacanal, Guinea, India, Malaysia, Nigeria, Pakistan, Papua New Guinea, Sierra Leone, Sri Lanka, Sudan, Tanzania, Thailand, USA
C. oryzae	*Oryza, Pennisetum, Zea*	Egypt, India, Indochina, Kenya, Pakistan, Thailand
C. ovoidea	*Capsicum, Pennisetum, Zea*	Egypt, India, Japan
C. penniseti	*Pennisetum, Sorghum, Triticum*	Australia, India, Nepal, Nigeria, Pakistan, Zimbabwe

*Information derived from Sivanesan (1987); used with permission of CAB International. Not all *Pennisetum* hosts are *P. glaucum*.
† Known to have a *Cochliobolus* teleomorph.

included in the geographic distribution of the pathogen. Despite this information,

> THIS PATHOGEN HAS NOT BEEN REPORTED ON PEARL MILLET IN THE UNITED STATES, AND ALL EFFORTS TO RESTRICT ITS ENTRY SHOULD BE CONTINUED.

Sclerospora graminicola has been reported on pearl millet in the countries listed below.

Africa: Chad, Egypt, Gambia, Malawi, Mozambique, Niger, Nigeria, Senegal, South Africa, Zimbabwe. Also Burkina Faso, Ghana, Ivory Coast, Kenya, Mali, Sudan, Tanzania, Togo, Uganda, Zambia (S.B. King, personal communication, 1995).

Asia: India, Pakistan. Also Israel (S.B. King, personal communication, 1995).

Nomenclature discrepancies: *Synonym: Scleropthora macrospora* (for example: Manivasakam et al. 1986, Mangath 1986).

Alternative disease name: Green ear disease.

Seed transmission: Evidence for transmission by seed is inconsistent and controversial. It has been suggested that this disease can be transmitted by oospores on the seed surface. To prevent introduction of *S. graminicola,* seed treatment is recommended.

Primary citation: Singh et al. 1993.

Downy Mildew

Plasmopara penniseti Kenneth & Kranz.

Symptoms: Small, diffuse, water-soaked stripes or spots expand to irregular brown stripes between the veins. Stripes may coalesce and turn necrotic. Streaks may enlarge beyond veins and turn greyish brown. "Down" of asexual sporulation is profuse and whitish to dingy. Only local lesions form. Usually only the lower leaves are affected.

Pathogen and disease characteristics: Sporangiophores emerge from stomata, branched dichotomously once or twice, then irregularly branched monopodially to subdichotomously two or three times at right angles. Oospores have not been observed.

Host range: Pearl millet.

Geographic distribution: Ethiopia.

Nomenclature discrepancies: Use of "downy mildew" as the common name for this disease may cause confusion with the more serious systemic disease caused by *Sclerospora graminicola.*

Seed transmission: Not known to be transmitted by seed.

Primary citations: Kenneth and Kranz 1973.

Drechslera Leaf Spot

Drechslera dematioidea (Bubak & Wroblewski) Subram. & Jain

Symptoms: Infection of seedlings results in 1- to 3-mm long coalescing lesions with extensive necrosis (Wilson and Hanna 1992).

Pathogen and disease characteristics: Conidia are 20–70 × 10–16 µm, straight, cylindrical to clavate, and rounded at the ends; golden brown to dark brown; and thick-walled, with 2 to 7 (commonly 3 or 4) septae.

Host range: Pearl millet, *Agrostis, Anthoxanthum, Avena, Cynodon, Dactylis, Eragrostis, Festuca, Hordeum, Lolium, Paspalum, Phleum,* and *Triticum.* Also isolated from *Iris, Leucospermum, Pinus,* and *Pseudotsuga.*

Geographic distribution: Australia, Europe, India, New Zealand, North America, South Africa.

Nomenclature discrepancies: *Synonyms or similar pathogens: Helminthosporium dematioideum* Bubak & Wroblewski, *Helminthosporium tetramera* McKinney (Yadav et al. 1975).

Seed transmission: Seedborne.

Primary citation: Sivanesan 1990b.

Ergot

Claviceps fusiformis Loveless

Symptoms: Cream to pink mucilaginous droplets of "honeydew" ooze out of infected

florets on pearl millet panicles. Within 10 to 15 days, the droplets dry and harden, and dark brown to black sclerotia develop in place of seeds on the panicle. Sclerotia are larger than seeds and are irregularly shaped. They generally get mixed with the grain during threshing.

Pathogen and disease characteristics: Sclerotia germinate to form 1 to 16 fleshy stipes, 6 to 26 mm long. Each stipe bears an apical, globular capitulum, light to dark brown, with numerous perithecial projections. Asci are interspersed with paraphyses and emerge through ostioles. Threadlike ascospores are hyaline, aseptate, and measure 100–170 × 0.5–0.7 μm.

Sclerotia germinate following rain. Ascospores infect emerged stigmas before pollination. Conditions favoring the disease are relative humidity greater than 80 percent and 20 to 30 °C temperatures. Honeydew production promotes secondary infection caused by asexual conidia. Honeydew consists of two types of asexual conidia.

Host range: Pearl millet, *Cenchrus ciliaris, Panicum antidotale, Pennisetum hohenackeri* Hochst. Also *P. squamulatum* and *P. massaicum* (Dwarakanath Reddy et al. 1969).

Geographic distribution:

THIS PATHOGEN HAS NOT BEEN REPORTED ON PEARL MILLET IN THE UNITED STATES AND ALL EFFORTS TO RESTRICT ITS ENTRY SHOULD BE CONTINUED.

Countries where pearl millet ergot has been observed or reported include:

Africa: Botswana, Burkina Faso, Gambia, Ghana, Malawi, Niger, Senegal, Somalia, Tanzania, Uganda, Zambia, Zimbabwe. Also Benin, Cameroon, Chad, Togo, Ivory Coast, Kenya, Mali, Nigeria, Sudan (S.B. King, personal communication, 1995).

Asia: India, Pakistan.

Nomenclature discrepancies: *Synonyms or similar pathogens: Claviceps microcephala* (Wallr.) Tul., *Sphacelia* spp., *Cerebella sorghi-vulgaris* Subram. (Wallace and Wallace 1949).

Alternative disease name: Asali disease.

Seed transmission: Sclerotia can contaminate seed lots. A 10-percent NaCl solution is effective for separating sclerotia and fragments from seed by flotation. This technique can be used only for relatively small quantities of seed. Sclerotia can be removed from small individual seedlots by hand.

Primary citation: Thakur and King 1988.

Ergot

Claviceps africana Frederickson, Mantle, & de Milliano

Symptoms: Sphacelial (conidial) "honeydew" sporulation has been reported on pearl millet (Frederickson and Mantle 1996). Formation of sclerotia has not been reported.

Pathogen and disease characteristics: Occurrence of the disease has usually been the result of artificial inoculation, except for the observation by Sundaram (1974), which, because of the location, may have been *Claviceps sorghi.*

From sorghum: Sclerotia (4–6 × 2–3 mm) bear a small distal sphacelial cap. White medulla is bound by thin red-brown cortex. Flower parts are persistent on sclerotia. Stromata are initially pale, translucent, and proliferate from sclerotium at one or two places. Stipes are purple in distal part of stipe. Stipes measure 8–15 × 0.3–0.6 mm; capitula are subglobose, 0.5–1.3 mm; perithecia measure 86–135 × 123–226 μm; ascospores usually up to 45 × 0.8–1.2 μm. Macroconidia are hyaline, mononucleate, oblong to oval, slightly constricted at center with a vacuole at each end, 9–17 × 5–8 μm. Microconidia are hyaline, mononucleate, spherical, 2–3 μm diameter (Frederickson et al. 1991).

Host range: Sorghum, pearl millet, guineagrass *(Panicum maximum).* The literature is not clear.

Geographic distribution: Infection on pearl millet has been observed in Zimbabwe and possibly in Nigeria and India. Geographic distribution of the pathogen on sorghum is wider than that reported for pearl millet.

Nomenclature discrepancies: The literature suggests cross-infection of pearl millet with *Sphacelia sorghi* McRae. Futrell and Webster (1966) reported that 1 percent of inoculated florets became infected in Nigeria. Sundaram (1974) reports infections in India, with subsequent cross-inoculations onto sorghum and pearl millet. Few experimental details are described. Dwarakanath Reddy et al. (1969) produced 20-percent infection on pearl millet. Frederickson and Mantle (1996) achieved successful inoculations with *C. africana.* Frederickson et al. (1991) indicate that there are at least two *Claviceps* species—*C. africana* and *C. sorghi*—that have been lumped under *Sphacelia sorghi* in the literature.

Seed transmission: No information available. Literature does not indicate if sclerotia form in pearl millet.

Primary citation: Frederickson and Mantle 1996.

Exserohilum Leaf Blight

*Exserohilum rostratum (*Drechs.) K.J. Leonard & E.G. Suggs

Symptoms: Foliar lesions (1–2 × 2–5 mm) are straw colored with brown margins. Lesions are often dark brown at first and then become light brown. Blighting often occurs on leaf tips and margins.

Pathogen and disease characteristics: Pigmented conidia are quite variable but approximately 200 × 8 µm, straight or slightly curved, and rostrate shaped. There are 6 to 16 septa. Terminal septa are particularly dark and thickened. A distinct hilum forms on the basal cell.

Host range: Pearl millet, maize, sorghum, *Setaria italica* (L.) Beauv., *Eleusine coracana* Garten.

Geographic distribution: India, United States.

Nomenclature discrepancies: *Synonyms: Drechslera rostrata, Exserohilum rostrata* (Drechs.) Shoem., *Helminthosporium rostratum* Drechs.

Seed transmission: Can be isolated from seed (table 4). Seedling infection from contaminated seed has not been demonstrated.

Primary citations: Young et al. 1947, Mohan et al. 1988.

False Mildew

Beniowskia sphaeroidea (Kalchbr. & Cke.) Mason

Symptoms: Small, white, cushion-shaped sporodochia, circular to elongate (1.5 mm long), are formed singly and in clusters on leaves. Infected leaves become chlorotic and necrotic from the point of infection to the apex of the leaf.

Pathogen and disease characteristics: A network of aerial hyphae culminate in spirally twisted, corkscrew apices at the periphery of the sporodochium. Hyphae are hyaline to very light tan. Conidia are hyaline and spherical, averaging 10 µm in diameter. Spores may have imperceptible roughenings and may be borne in short chains.

Host range: *Andropogon marginatus* Steud., *Chaetochloa poiretiana* Hitchc. [=*Setaria poiretiana* (Schult.) Kuntz.], *Panicum palmifolium* Willd. (=*Setaria palmifolia* (Willd.) Stapf.), *Pennisetum japonicum* Trin., *P. nepalense* Spreng., *P. purpureum* Schumach, *Setaria aurea* Hochst., *S. geniculata, S. verticillata* (L.) Beauv., and *Sorghum vulgare* Pers.

Geographic distribution: On pearl millet: Malawi (Wiehe 1953), Tanzania (Mbwaga et al. 1993), Zimbabwe (Mtisi and de Milliano 1991). On other hosts: Japan, Java, Malawi, South Africa, Sudan, Trinidad, Uganda, United States, Zimbabwe.

Nomenclature discrepancies: *Synonyms or similar pathogens: Albugo* sp., *Beniowskia penniseti* Wakefield, *B. sphaeroideum* Kalchbr. & Cke., *Ceratium sphaeroideum* Kalchbr. & Cke.

Seed transmission: Not known to be transmitted by seed.

Primary citations: Taber et al. 1978, Brown and Hanlin 1982.

Head Mold

Various species of fungi (see table 4)

Symptoms: Pink, white, brown, or grey fungal growth on grain. Apparently asymptomatic seed may be contaminated.

Pathogen and disease characteristics: Many pathogens cause preharvest grain molds. Grain molds on pearl millet tend to be more severe with humid conditions during grain fill (Wilson et al. 1993, Ingle and Raut 1994) and if grain harvest is delayed (Wilson et al. 1995). Several fungi cause grain molds, and these differ by the region of cultivation, crop management, environmental conditions prior to harvest, and storage conditions.

Host range: See information in this text for specific pathogens listed in table 4.

Geographic distribution: See information in this text for specific pathogens listed in table 4.

Nomenclature discrepancies: See information in this text for specific pathogens listed in table 4.

Seed transmission: These fungi are seedborne by definition. Not all are pathogenic to seedlings.

Primary citations: See table 4.

Table 4. Fungi isolated from pearl millet seed

Seed source	Fungal isolate	Recognized pathogen?	Reference
India	*Alternaria longissima*	No	Mathur et al. 1973
	Botrytis cinerea	No	
	Chaetomium globosum	No	
	Curvularia oryzae	Possible	
	Curvularia pallescens	Possible	
	Curvularia penniseti	Yes	
	Curvularia siddiquii	Possible	
	Drechslera hawaiiense	Possible	
	Drechslera longirostrata	Possible	
	Drechslera maydis	Possible	
	Drechslera rostrata (=*Exserohilum rostratum*)	Yes	
	Drechslera tetramera	Yes	
	Epicoccum purpurascens	No	
	Fusarium equiseti	No	
	Fusarium fusarioides	No	
	Fusarium moniliforme	Yes	
	Fusarium semitectum	No	
	Phaeotrichoconis crotalariae	No	
	Phoma spp.	Possible	
	Trichoconis padwickii	No	
India (?)	*Alternaria alternata*	Possible	Konde et al. 1980
	Aspergillus nidulans	No	
	Aspergillus ochraceus	No	
	Aspergillus terreus	Possible	
	Chaetomium brasiliense	No	
	Cladosporium oxysporum	No	
	Curvularia lunata	Possible	

Continued

Table 4. Fungi isolated from pearl millet seed — Continued

Seed source	Fungal isolate	Recognized pathogen?	Reference
	Drechslera australiensis	Possible	
	Fusarium moniliforme	Yes	
	Fusarium solani	Possible	
	Penicillium cyclopium	No	
	Periconia saraswatipunsis	No	
	Phoma herbarum	No	
	Rhizoctonia bataticola	Possible	
	Syncephalastum racemosum	No	
India	*Drechslera setariae* (=*Bipolaris setariae*)	Yes	Shetty et al. 1982
India (?)	*Aspergillus flavus*	No	Girisham et al. 1985
	Aspergillus nidulans	No	
	Aspergillus ochraceus	No	
	Aspergillus terreus	No	
	Fusarium moniliforme	Yes	
	Fusarium oxysporum	No	
	Fusarium semitectum	No	
	Fusarium solani	No	
	Myrothecium roridum	Yes	
	Penicillium citrinum	No	
	Stachybotrys atra	No	
	Trichothecium roseum	No	
India	*Absidia* spp.	No	Mishra and Daradhiyar 1991
	Alternaria alternata	Possible	
	Aspergillus candidus	No	
	Aspergillus clavatus	No	
	Aspergillus flavus	No	
	Aspergillus luchuensis	No	
	Aspergillus niger	No	
	Aspergillus sulphereus	No	
	Aspergillus sydowi	No	
	Chaetomium globosum	No	
	Cunninghamella spp.	No	
	Curvularia geniculata	Possible	
	Curvularia pallescens	Possible	
	Fusarium moniliforme	Yes	
	Fusarium spp.	No	
	Geotrichum spp.	No	
	Helminthosporium spp.	Possible	
	Penicillium spp.	No	
	Rhizopus spp.	Possible	
	Sepedonium spp.	No	
	Tubercularia spp.	No	
	Mycelia sterilia	No	

Table 4. Fungi isolated from pearl millet seed

Seed source	Fungal isolate	Recognized pathogen?	Reference
India	*Bipolaris sacchari*	Yes	Ahmed and Reddy 1993
	Bipolaris setariae	Yes	
	Claviceps fusiformis	Yes	
	Curvularia penniseti	Yes	
	Pyricularia penniseti	Yes	
	Sclerospora graminicola	Yes	
	Tolyposporium penicillariae	Yes	
India	*Alternaria tenuis*	No	Ingle and Raut 1994
	Curvularia lunata	Yes	
	Drechslera sacchari (=*Bipolaris sacchari*)	Yes	
	Exserohilum halodes	Possible	
	Fusarium moniliforme	Yes	
	Phoma spp.	Possible	
Lesotho	*Fusarium equiseti*	No	Onyike et al. 1991
Namibia	*Fusarium nygamai*	No	Marasas et al. 1988
Nigeria	*Fusarium moniliforme*	Yes	Onesirosam 1975
Nigeria	*Fusarium chlamydosporum*	No	Onyike et al. 1991
	Fusarium equiseti	No	
	Fusarium moniliforme	Yes	
	Fusarium napiforme	No	
	Fusarium nygamai	No	
	Fusarium semitectum	No	
	Fusarium subglutinans	No	
USA	*Curvularia lunata*	Possible	Luttrell 1954
	Fusarium spp.	Possible	
	Helminthosporium rostratum (=*Exserohilum rostratum*)	Yes	
	Helminthosporium stenospilum (=*Bipolaris stenospilum*)	Possible	
	Oidium tenellum	No	
USA	*Alternaria* spp.	No	Luttrell et al. 1955
	Aspergillus spp.	No	
	Curvularia spp.	Possible	
	Fusarium spp.	Possible	
	Helminthosporium stenospilum (=*Bipolaris stenospilum*)	Possible	
	Penicillium spp.	No	
	Pythium spp.	Possible	
	Rhizopus spp.	Possible	
	Trichoderma spp.	No	
	Verticillium spp.	No	

Continued

Table 4. Fungi isolated from pearl millet seed — Continued

Seed source	Fungal isolate	Recognized pathogen?	Reference
USA	*Alternaria* spp.	No	Wells and Winstead 1965
	Curvularia spp.	Possible	
	Fusarium moniliforme	Yes	
	Fusarium spp.	No	
	Helminthosporium rostratum (=*Exserohilum rostratum*)	Yes	
	Helminthosporium setariae (=*Bipolaris setariae*)	Yes	
USA	*Alternaria* spp.	No	Wilson et al. 1993
	Aspergillus flavus	No	
	Bipolaris setariae	Yes	
	Cladosporium spp.	No	
	Curvularia spp.	Possible	
	Drechslera dematioidea	Yes	
	Epicoccum spp.	No	
	Exserohilum rostratum	Yes	
	Fusarium chlamydosporum	No	
	Fusarium equiseti	No	
	Fusarium moniliforme	Yes	
	Fusarium semitectum	No	
	Fusarium, miscellaneous spp.	No	
	Gloeocercospora sorghi	Yes	
	"Helminthosporium" spp.	Possible	
	Penicillium spp.	No	
	Phyllosticta penicillariae	Yes	
Zimbabwe	*Fusarium chlamydosporum*	No	Onyike et al. 1991
	Fusarium equiseti	No	
	Fusarium moniliforme	Yes	
	Fusarium napiforme	No	
	Fusarium nygamai	No	
	Fusarium oxysporum	No	
	Fusarium semitectum	No	

Myrothecium Leaf Spot

Myrothecium roridum Tode ex Fr

Symptoms: Water-soaked oval spots on leaves rapidly increase in size and turn dirty brown. Necrotic tissue can crack and develop holes.

Pathogen and disease characteristics: In culture, sporodochia are sessile, up to 1.5 mm in diameter, and often confluent. Spore masses are viscous and green at first, later becoming hard and black. No setae in sporodochia. Conidia are cylindrical with rounded ends, colorless to pale olive green to black in mass, and mostly 6–8 × 1.5–2.5 µm (Ellis 1971, Barron 1968).

Host range: Pearl millet, guar [*Cyamopsis tetragonoloba* (L.) Taub], moth (*Phaseolus*

acontifolius Jacq.), black gram (*Phaseolus mungo* L.), green gram [*Vigna radiata* (L.) Wilkzee], pigeonpea [*Cajanus cajan* (L.) Millsp.], cowpea (*Vigna sinensis* Endl.), pea (*Pisum sativum* L.), soybean (*Glycine max* Merr.), peanut (*Arachis hypogaea* L.), okra [*Abelmoschus esculantum* (L.) Moench.], cotton (*Gossypium hirsutum* L. and *Gossypium arboreum* L.), potato (*Solanum tuberosum* L.), tomato (*Lycopersicum esculentum* Mill), eggplant (*Solanum melongena* L.), wheat (*Triticum aestivum* L.), maize (*Zea mays* L.) (Gaikwad 1988).

Geographic distribution: India. A *Myrothecium* species has been isolated from pearl millet stalks in the United States, but the species appears to be *M. verracaria* (J.P. Wilson, personal observation).

Nomenclature discrepancies: None.

Seed transmission: Can be isolated from seed (Girisham et al. 1985).

Primary citations: Ellis 1971, Barron 1968.

Phyllachora Leaf Spot

Phyllachora penniseti Syd.

Symptoms: Leaves can be covered with numerous small, elongate, dark or black pustules that are 2–3 mm long when isolated but become confluent in mass. Both surfaces of the leaves can be affected. Symptoms usually develop after most vegetative growth has occurred or during grain fill.

Pathogen and disease characteristics: Pseudopycnidia develop in the stroma under the epidermis. Elliptical, cylindrical, unicellular, hyaline conidia measure 10–15 × 2.5–3 μm in diameter.

Host range: Pearl millet, napiergrass (Moreau 1949). Also described on *Pennisetum benthami* Stend. (Saccas 1954).

Geographic distribution: Chad, Niger, Tanzania (Wallace and Wallace 1949). Republic of Guinea (and possibly Uganda, see below) on napiergrass (Moreau 1949).

Nomenclature discrepancies: *Synonyms or similar pathogens:* Described as anamorphic *Placosphaeria* sp. in Saccas (1954) and Jouan and Delassus (1971). *Leptosphaeria penniseti* was isolated from napiergrass in Uganda and was associated with *Phyllachora* and *Stagonospora* (Moreau 1949). Saccas (1954) indicates asci and ascospore dimensions of *L. penniseti* were consistent with *Phyllachora penniseti,* although dimensions of *L. penniseti* differ from *P. penniseti* in Moreau (1949).

Alternative disease name: Tar spot.

Seed transmission: Not demonstrated to be transmitted by seed.

Primary citations: Saccas 1954, Jouan and Delassus 1971.

Phyllosticta Leaf Blight

Phyllosticta penicillariae Speg.

Symptoms: Seedlings can be stunted and chlorotic. Leaf lesions measure approximately 5 × 2.5 mm. Lesions are generally parallel sided with dark brown margins and light brown necrotic centers. Coalesced lesions usually result in tattered leaf tissue. Leaf margins are frequently necrotic. Pycnidia form in necrotic tissue.

Pathogen and disease characteristics: Pycnidia average 75.8 μm in diameter. Conidia are hyaline, single celled, biguttulate, elliptical, and approximately 6.2 × 2.8 μm.

Host range: Pearl millet, possibly napiergrass.

Geographic distribution: Chad, Niger, Senegal (Spegazzini 1914), continental United States. A *Phyllosticta* sp. was reported on napiergrass in Hawaii (Raabe et al. 1981). A *Phoma* sp. was isolated from seed in India (Mathur et al. 1973) and possibly Tanzania (Mbwaga et al. 1993).

Nomenclature discrepancies: *Synonyms or similar pathogens:* Reference to *Phoma* spp. on seed (Mathur et al. 1973) and *Phoma sorghina* (Sacc.) Boerema on foliage (Mbwaga et al. 1993) may be *P. penicillariae.*

Seed transmission: Can be isolated from seed

(Wilson et al. 1993). Seedling infection from contaminated seed has not been demonstrated.

Primary citations: Saccas 1954, Jouan and Delassus 1971, Wilson and Burton 1990.

Pyricularia Leaf Spot

Pyricularia grisea (Cke.) Sacc

Symptoms: Lesions on foliage are elliptical or diamond shaped, approximately 2.5–3.5 × 1.5–2.5 mm. Lesion centers are grey and water soaked when fresh but turn brown on drying. Lesions are often surrounded by a chlorotic halo, which turns necrotic, giving the appearance of concentric rings.

Pathogen and disease characteristics: Asexual conidia are pyriform, hyaline, mostly three celled with a small appendage on the base cell. Conidia measure approximately 17.5–30.8 × 5.9–8.8 μm. (Mehta et al. 1953). Germination, appresoria formation, and invasion of host cells are greatest at 25 °C (Yadava and Agnihotri 1980).

Host range: Pearl millet, napiergrass *(Pennisetum purpureum)* (Buckley and Allen 1951).

Geographic distribution: India, Singapore (on napiergrass, Buckley and Allen 1951), United States.

Nomenclature discrepancies: *Synonyms: Piricularia* spp. (Mehta et al. 1953), *P. grisea* (Wells et al. 1969), *Pyricularia penniseti* (Prasda and Goyal 1970, Singh and Pavgi 1974), *P. setariae* (Rachie and Majmudar 1980).

Alternative names for the disease: Blast (Buckley and Allen 1951), brown leaf spot (Singh and Pavgi 1974), leaf blast (Rachie and Majmudar 1980), leaf spot disease (Mehta et al. 1953, Prasda and Goyal 1970), piricularia leaf spot (Wells et al. 1969).

Seed transmission: Ahmed and Reddy (1993) have suggested that seed infection occurs. However, note that in the "Head Mold" section, isolation of *P. grisea* from seed has never been reported by other researchers (table 4). Transmission to seedlings has not been demonstrated.

Primary citations: As indicated above.

Rhizoctonia Blight

Rhizoctonia solani Kühn
Rhizoctonia zeae Voorhees

Symptoms: Disease can be expressed as seed decay, pre-emergence and postemergence damping off, stem lesions on seedlings, or stem canker on more mature plants. Invasion of sheath and blade tissue can cause a banding pattern. The midrib is usually the last part of the leaf killed. Mature plants have considerable accumulation of dead brown leaves around the base. Individual culms may be killed. The root system is reduced, with extensive killing and discoloration.

Pathogen and disease characteristics: *Rhizoctonia* species often survive in soil as melanized hyphae and sclerotia, often associated with plant debris. *R. solani* forms yellow-brown, matlike stroma and distinct sclerotia in culture. *R. zeae* forms a white to pink mycelium and spherical, reddish brown sclerotia immersed throughout agar medium. Classification of *Rhizoctonia* species is currently based on hyphal characteristics and colony morphology in culture (Sneh et al. 1991).

Host range: Nearly all plants are susceptible to one or more anastomosis groups of *R. solani* or binucleate *Rhizoctonia* species. Some host specificity exists among the different anastomosis groups of *R. solani.* Pathogens of pearl millet have not been examined for anastomosis compatibility. *R. zeae* is primarily a pathogen of many different grasses.

Geographic distribution: On pearl millet: United States, Tanzania (Mbwaga et al. 1993).

Nomenclature discrepancies: *Synonyms: Pellicularia filamentosa* (Pat.) Rogers f. *solani* (Kühn) Exner.

Alternative names for the disease: Banded sheath, leaf blight, soil rot.

Seed transmission: Not known to be transmitted by seed. Konde et al. (1980) has reported isolation of *Rhizoctonia bataticola* from seed, but the fungus is now considered *Sclerotium bataticola* Taub [teleomorph: *Macrophomina phaseolina* (Tassi) G. Goid.]

Primary citations: Luttrell 1954, Weber 1963.

Rust

Puccinia substriata Ell. & Barth. var. *indica* Ramachar & Cumm.

Symptoms: On pearl millet: small, reddish brown to reddish orange, round to elliptical uredinia develop mainly on foliage. As severity of infection increases, leaf tissue will wilt and become necrotic from the leaf apex to base. In infection sites developing late in the season, uredinia are replaced by telia, which are black, elliptical, and subepidermal.

Pathogen and disease characteristics: *P. substriata* var. *indica* is a macrocyclic rust with the uredinial, telial, and basidial stages formed on pearl millet. Urediniospores are generally elliptical, measuring 35 × 25 μm, with four equatorial germpores. Spores have yellowish brown walls and are sparely echinulate, more predominantly near the apex. Teliospores are generally two celled, although this can vary. Dark brown, club-shaped spores measure 49 × 21 μm, and are borne on a pedicel. The spermagonial and aecial stages develop on the alternate *Solanum* hosts.

Uredinial sori may occasionally be parasitized by *Darluca filum* (Biv.), which forms pycnidia with two-celled conidia (Ramakrishnan and Narasimhalu 1941).

Host range: Uredinial hosts: Pearl millet, *Panicum antidotale, P. maximum, Pennisetum orientale, P. violaceum.* Also *Pennisetum polystachyon* (Ramakrishnan and Sundaram 1956).

Aecial hosts: Eggplant (*Solanum melongena* L.), *S. torvum* Sw., *S. xanthocarpum* Schrad & Wendl., *S. anguivi* Lam., *S. ferox* L., *S. incanum* L., *S. linnaeanum* Hepper & P. Jaeger, *S. gilo* Raddi, *S. nodiflorum* Jacq., *S. rostratum* Dunal (Wilson et al. 1996b), *S. melongena* var. *insanum* Prain, and *S. pubescens* Willd. (Ramakrishnan and Sundaram 1956). *Euphorbia pulcherimma* Willd. (Rao et al. 1986) has also been reported as an aecial host, but the report is subject to some question.

Geographic distribution: United States; also Brazil (C.T. Hash, personal communication, 1999.

Asia: India, Sri Lanka, Pakistan.

Africa: Chad, Congo, Ethiopia, Ghana, Guinea, Ivory Coast, Kenya, Malawi, Mozambique, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe. Also Burkina Faso (S.B. King, personal communication, 1995).

Infection of the aecial host has been reported in Brazil (Figueiredo et al. 1971), India (Dalela and Mathur 1970), and the United States (Wilson and Williamson 1997).

Nomenclature discrepancies: *Synonyms: Puccinia penniseti* Zimm., *Puccinia substriata* Ell. & Barth. var. *penicillariae* (Speg.) Stat.

Other rust pathogens reported on pearl millet: Puccinia stenotaphri Cummins (Sathe 1969) [probably a synonym; the description of the fungus is similar to that in Wells et al. (1973)], *Puccinia substriata* Ell. & Barth. var. *decrospora* (Eboh 1986).

Seed transmission: Not known to occur.

Primary citation: Singh and King 1991.

Seedling Blight

Various species of fungi (see table 5)

Symptoms: The disease is expressed as preemergence and postemergence damping off or stunted seedling growth.

Pathogen and disease characteristics: Many pathogens cause seedling blight. They are often associated with grain molds, foliar blights, or stalk rots. Seedling blight tends to be more severe during cool temperatures (Hart and Wells 1965, Wells and Winstead 1965).

Host range: See information in this text for specific pathogens listed in table 5.

Geographic distribution: See information in this text for specific pathogens listed in table 5.

Nomenclature discrepancies: See information in this text for specific pathogens listed in table 5.

Seed transmission: Pathogens causing seedling blight are often associated with grain molds and may be transmitted by seed. See information in this text for specific pathogens listed in table 5.

Primary citations: See table 5.

Smut

Moesziomyces penicillariae (Bref.) Vanky

Symptoms: Immature, green sori larger than the seed develop on panicles during grain fill. A single sorus develops per floret. As grain matures, sori change in color from green to dark brown. Sori are filled with dark teliospores.

Table 5. Fungi reported to cause pre-emergence or postemergence damping off and seedling blight of pearl millet

Seed source	Fungal isolate	Disease symptoms	Reference
India	*Chaetomium globosum*	Reduced germination	Mathur et al. 1973
	Curvularia penniseti	Reduced germination, seedling blight	
	Drechslera maydis	Reduced germination	
	Drechslera rostrata (=*Exserohilum rostratum*)	Reduced germination	
	Drechslera tetramera	Reduced germination	
	Fusarium equiseti	Reduced germination	
	Fusarium fusarioides	Reduced germination	
India (?)	*Alternaria alternata*	Leaf spots, marginal necrosis	Konde et al. 1980
	Aspergillus terreus	Root and stem lesions	
	Curvularia lunata	Leaf lesions	
	Drechslera australiensis	Seedling blight, leaf spots	
	Fusarium moniliforme	Reduced germination, seedling blight	
	Fusarium solani	Reduced germination, seedling blight	
	Rhizoctonia bataticola	Foliar lesions	
India	*Drechslera setariae* (=*Bipolaris setariae*)	Reduced germination, seedling blight	Shetty et al. 1982
Nigeria	*Fusarium moniliforme*	Reduced germination	Onesirosan 1975
USA	*Fusarium moniliforme*	Reduced emergence	Wells and Winstead 1965
	Helminthosporium rostratum	Reduced emergence	
	Helminthosporium setariae	Reduced emergence	
USA	*Phyllosticta penicillariae*	Seedling blight	Wilson and Burton 1990

Pathogen and disease characteristics: Chestnut brown to black-brown sporeballs are composed of 200 to 1,400 aggregated yellowish brown globose to subglobose teliospores. Teliospores germinate to produce promycelia with basidiospores and sporidia (Subba Rao and Thakur 1983). Infection occurs when sporidia suspended in rain or dew infiltrate into the boot (Wilson 1995). Aerial populations of sporidia are greatest when minimum and maximum temperatures range between approximately 21 and 31 °C and maximum relative humidity is greater than 80 percent (Kousik et al. 1988).

Host range: Pearl millet.

Geographic distribution: United States (Wells et al. 1963), India, Zimbabwe, Senegal, Chad, Niger, Nigeria, Malawi (Wiehe 1953, Saccas 1954, King 1970, Jouan and Delassus 1971, Rachie and Majmudar 1980), and Tanzania (Mbwaga et al. 1993). Also Zambia, Sudan, Cameroon, Burkina Faso, Ghana, Mali (S.B. King, personal communication, 1995).

Nomenclature discrepancies: *Synonyms: Tolyposporium penicillariae* Bref. (Vanky 1977), *Tolyposporium senegalense* Speng.

Considerable confusion exists in the literature concerning smut of pearl millet. For further details, see "Questionable or poorly described diseases of pearl millet reported in the literature," p. 32.

Seed transmission: Seed may be infested with teliospore balls, but infection does not take place through seedlings (Bhatt 1946). Teliospores may remain viable in the soil, where basidiospores and sporidia may be produced (Patel et al. 1959).

Primary citations: As indicated above.

Southern Blight

Sclerotium rolfsii Sacc.

Symptoms: Disease is expressed as seed decay, pre-emergence and postemergence damping off, stem lesions on seedlings, or stem cankers on more mature plants. Infection and rot are restricted to lower stem. Mature plants have considerable accumulation of dead brown leaves around the base. Root system is much reduced, with extensive killing and discoloration.

Pathogen and disease characteristics: White mycelium and brown sclerotia often visible at the base of the plant.

Host range: Very wide. Nearly all are annuals.

Geographic distribution: United States (for pearl millet).

Nomenclature discrepancies: *Synonym: Pellicularia rolfsii* (Sacc.) West.

Alternative disease name: White mold.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Weber 1963.

Top Rot

Fusarium moniliforme Sheldon

Symptoms: The panicle and immature leaves often remain in the whorl, where they become rotted and covered with a mass of white mycelium. Nodes will frequently be discolored.

Pathogen and disease characteristics: Microconidia are abundant, primarily single celled, and formed in long chains and in false heads (Nelson et al. 1983).

Host range: Numerous Gramineae. "Top rot" symptoms can occur on pearl millet, sugarcane, and sorghum.

Geographic distribution: On pearl millet, only the United States and India. On sugarcane, Australia, India, continental United States, Hawaii (Ramakrishnan 1941).

Nomenclature discrepancies: *Alternative disease names:* Twisted top, pokkah boeng, pokkah bong (name for disease on sugarcane).

Seed transmission: *F. moniliforme* is frequently isolated from seed (see table 4).

Primary citation: Wells 1956.

Zonate Leaf Spot

Gloeocercospora sorghi Bain & Edgerton

Symptoms: Foliar lesions appear as water-soaked spots that develop tan centers and dark brown borders and measure 3.5–5 × 2–3.5 mm. Spots enlarge, forming roughly semicircular blotches covering about half of the leaf width. Blotches are various shades of dark brown mottled with pale tan spots that may appear as concentric rings of alternating tan and brown.

Note that disease symptoms of zonate leaf spot illustrated in Williams et al. (1978) were later attributed to dactuliophora leaf spot (Tyagi 1985). Symptom expression of and differentiation between these two diseases need to be clarified.

Pathogen and disease characteristics: Conidia borne on short, erumpent stromata are attenuate-obclavate, hyaline, multiseptate, and approximately 74.5 × 2.2 μm. In moist weather, tiny, salmon-colored globules of conidial masses on the foliar lesions are visible with a hand lens.

Host range: Pearl millet, sorghum.

Geographic distribution: United States, Tanzania (Wallace and Wallace 1949), Malawi (Wiehe 1953).

Nomenclature discrepancies: None.

Seed transmission: Very infrequently isolated from seed (Wilson et al. 1993). Transmission by seed has not been demonstrated.

Primary citation: Luttrell 1954.

Viral Diseases

Black-Streaked Dwarf Virus

Symptoms: Stunting or dwarfing occurs, particularly if plants are infected in the seedling stage. Symptoms on pearl millet are not well documented. On maize, white waxy swellings occur on veins. Foliage is dark green with chlorotic streaks, and there is splitting of leaf margins (McGee 1988).

Pathogen and disease characteristics: Belongs to the Reoviridae fijivirus group (Park et al. 1994). Isometric particles are 75–80 nm in diameter (McGee 1988). Transmission occurs persistently by planthoppers.

Host range: Pearl millet, maize, rice, finger millet, barnyardgrass, *Isachne globosa*, barley, wheat, barnyard millet, *Digitaria sanguinalis* (Choi et al. 1989a,b), rye (McGee 1988).

Geographic distribution: South Korea, Japan (on maize).

Nomenclature discrepancies: *Alternative disease names:* Maize streaked dwarf, rice black-streaked dwarf.

Seed transmission: Not described in the literature. Probably not transmitted by seed (B.H. Choi, personal communication, 1995).

Primary citations: As above.

Guineagrass Mosaic Virus

Symptoms: Young diseased plants show lines of light green eyespots or a pale green mosaic, depending on the cultivar. Symptoms develop into a striped mosaic by elongation and coalescing of the eyespots. Some plants show severe symptoms plus dwarfing.

Pathogen and disease characteristics: This potyvirus is transmitted by aphids *(Hysteroneura setariae* and *Rhopalosiphum maidis),* probably nonpersistently, but it can be mechanically transmitted. Symptoms appear about 8 to 10 days after inoculation. Strain or host specificity may exist.

Host range: Pearl millet, *Bromus commutatus, B. macrostachys, Panicum crus-galli, P. maximum, Sorghum aroundinaceum, Zea mays.* Possibly *Paspalum conjugatum, Brachiaria brizantha, B. decumbens, B. dictyoneura, B. humidicola, B. jubata, B. ruzizensis* (Morales et al. 1994). Also *Brachiaria deflexa, Bromus arvensis, B. racemosus, B. sterilis, Coix lacryma-jobi, Echinochloa crus-galli, Oplismenus hirtelus, Panicum bulbosum, P. miliaceum, Paspalum racemosum, Setaria glaucum, S. italica, S. macrochaeta, S. verticillata, Stenotaphrum secondatum* (Thouvenel et al. 1976).

Geographic distribution: Ivory Coast (on pearl millet). Possibly Columbia and Brazil on other hosts (Morales et al. 1994).

Nomenclature discrepancies: None.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Kukla et al. 1984.

Indian Peanut Clump Virus

Symptoms: Not described in the literature.

Pathogen and disease characteristics: This furovirus is vectored by the soilborne fungus *Polymyxa* spp.

Host range: Pearl millet, peanut, finger millet *(Eleusine coracana),* foxtail millet *(Setaria italica).*

Geographic distribution: Natural distribution on pearl millet is not known. Occurrence has been confirmed in India.

Nomenclature discrepancies: None.

Seed transmission: Very low rate of transmission by seed (0.9 percent) has been observed in plants that had been grown in an infested field in India.

Primary citation: Reddy et al. 1998.

Maize Dwarf Mosaic Virus (MDMV)

Symptoms: Infected plants express mosaic and mild stunting.

Pathogen and disease characteristics: This potyvirus is generally transmitted by aphids (nonpersistently) or mechanically. Pearl millet is susceptible to "A" and "B" strains of MDMV. Symptom expression is not temperature sensitive. There appears to be strain specificity for some of the different hosts.

Host range: Pearl millet, maize, sorghum, johnsongrass, sudangrass, sand lovegrass, indiangrass, foxtail, barnyardgrass, large crabgrass, downy bromegrass, goosegrass, wild cane, sugarcane, teosinte, foxtail millet, plumegrass, napiergrass, *Chrysopogon montanus* Trin., finger millet *(Eleusine coracana* Garten.), rice (*Oryza sativa* L.), *Panicum miliaceum* L., *P. miliare* Lamk., *Paspalum scrobiculatum* L., *Themeda quadrivalvis* O. Kuntze, *Urochloa mosambicensis* (Hackel) Dandy, *U. stolonifera* (Goosens) Chippind.

Geographic distribution: "Widespread."

Nomenclature discrepancies: *Alternative disease names:* Sugarcane mosaic (this may be a different virus; see Krstic et al. 1995), grass mosaic, bajra mosaic.

Seed transmission: Transmission by seed in pearl millet has not been demonstrated. Very low frequency observed in maize.

Primary citations: Seth et al. 1972b, Rishi et al. 1973, Shurtleff 1980, Jensen et al. 1983.

Maize Streak Virus (MSV)

Symptoms: Chlorotic streaks on foliage are generally not severe. On inoculated seedlings, light-colored circular spots develop, usually on one side of the leaf and parallel to the midrib. Spots coalesce to form nearly uninterrupted chlorotic bands running the length of the leaf. New emerging leaves show well-developed chlorotic stripes along the length of the leaf (Seth et al. 1972a).

Pathogen and disease characteristics: This geminivirus is transmitted by at least eight leafhopper species.

Host range: Pearl millet, maize, sugarcane, wheat, barley, oats, finger millet *(Eleusine coracana),* African rice (*Oryza glaberrima* Steudel), *Axonopus compressus, Brachiaria lata, B. deflexa, B. distichophylla, Coix lacryma-jobi, Dactyloctenium aegyptium, Digitaria horizontalis, Eleusine indica, Echinochloa colonum, E. stagnina, Oryza sativa, Paspalum conjugatum, P. notatum, P. scrobiculatum, Panicum maximum, Pennisetum polystachion, Rhynchelytrum repens, Rottboellia cochinchinensis, Setaria barbata,* and many other hosts within the Gramineae.

Geographic distribution: Egypt, India, Madagascar, Malawi, Mauritius, Nigeria, Réunion, South Africa, Uganda.

Nomenclature discrepancies: *Alternative disease names:* Pennisetum strain of maize streak virus, bajra streak, sugarcane streak virus, panicum streak virus.

Numerous strains exist. Isolates from pearl millet cross-react with antisera from maize, panicum, and sugarcane isolates. Isolates from pearl millet probably belong to the panicum strain and appear to be too distantly related to MSV from maize to be important in relation to MSV in the field. Pearl millet is susceptible to the "eleusine strain," according to Nagaraju and Viswanath (1983). Later work (Briddon et al. 1996) indicates that isolates from pearl millet are most closely related to sugarcane streak virus.

Seed transmission: Not known to be transmitted by seed.

Primary citations: Shurtleff 1980, Nagaraju and Viswanath 1983, Mesfin et al. 1992.

Panicum Mosaic Virus (PMV)

Symptoms: Symptoms on pearl millet are expressed as a mild chlorotic mottle (Qiu et al. 1998). On switchgrass, stunting can be severe in susceptible plants. Mild green mosaic and mottling and yellow or light green blotchy mottling, mosaic, and streaking of leaves are characteristic. The entire plant or sectors of it can become chlorotic if badly stunted (Sill and Pickett 1957).

Pathogen and disease characteristics: 109S isometric virus, 28–30 nm in diameter. Single RNA (28S) and protein species (28,000 daltons). Six serotypes have been differentiated. A serological relationship exists between PMV and members of the phleum mottle virus group (Buzen et al. 1984).

The virus is mechanically transmitted. PMV is a warm-temperature virus. Incubation periods (7–18 days) are generally shorter at warmer, and longer at cooler, temperatures. Optimum symptoms develop on many hosts when temperatures are 29 to 35 °C. Virus remains infective in dessicated leaf tissue for up to 9 years (Sill and Talens 1962).

Host range: Switchgrass (*Panicum virgatum* L.), broomcorn millet (*P. miliaceum* L.), ticklegrass (*P. capillare* L.), panicgrass (*P. scribnerianum* Nash), Hall's panicum (*P. hallii* Vasey), foxtail millet [*Setaria italica* (L.) Beauv.], barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], crabgrass [*Digitaria sanguinalis* (L.) Scop.] (Sill and Pickett 1957). Also *Panicum ramosum, P. decompositum, P. turgidum, Setaria verticillata* (Sill and Talens 1962), *S. lutescens* (Sill and Desai 1960), maize *(Zea mays), Panicum dichtomiflorum* (Niblett et al. 1977), *P. virgatum* L., and St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] (Holcomb et al. 1989).

Note: Sill and Pickett (1957) indicate that pearl millet *(P. glaucum)* is immune to PMV. Buzen et al. (1984) indicated that PMV and its satellite virus were increased on pearl millet [*Setaria italica* (L.) Beauv.] [sic]. There was obviously a discrepancy in their host identification since *S. italica* is foxtail millet. Day et al. (1994) likewise referred to the host as pearl millet. Day sent a voucher specimen to me, and the host was confirmed to be pearl millet. Masuta et al. (1987) indicate that pearl millet was used to increase PMV.

Geographic distribution: USA (Kansas). St. Augustine decline strain (PMV-SADV) occurs in the USA (Arkansas, Louisiana, South Carolina, Texas) and Mexico (Holcomb et al. 1989).

Nomenclature discrepancies: *Synonyms:* St. Augustine decline virus (SADV) is a strain of PMV.

Seed transmission: Generally not known to be transmitted by seed (Sill and Desai 1960); however, transmission of an SADV strain by seed was reported in *Setaria italica* (Niblett et al. 1977).

Primary citations: As indicated above.

Satellite Panicum Mosaic Virus (SPMV)

Symptoms: Coinoculation of panicum mosaic virus (PMV) with its satellite virus (SPMV) results in a severe chlorotic mottle on pearl millet (Qiu et al. 1998).

Pathogen and disease characteristics: The virus is a mechanically transmitted 42S isometric particle, 17 nm in diameter, but it is not infectious alone. Contains two RNA species (14 and 34S) and a single protein (15,500 daltons). Satellite panicum mosaic virus is serologically unrelated to panicum mosaic virus (PMV), but depends on PMV for replication. Two serotypes are known (Buzen et al. 1984).

Host range: Host range is not well defined but is probably identical to that of panicum mosaic virus.

See note on panicum mosaic virus, page 24.

Geographic distribution: USA (Kansas).

Nomenclature discrepancies: None.

Seed transmission: Not known to be transmitted by seed.

Primary citations: As above.

Wheat Streak Mosaic Virus

Symptoms: Systemic mosaic symptoms expressed as mosaic with interveinal reddening, sometimes with necrosis within the red areas.

Pathogen and disease characteristics: This member of the Potyviridae is vectored by the wheat curl mite, *Aceria tosichella* Keifer. Mites are more efficient at vectoring than mechanical inoculation.

Host range: Pearl millet, sorghum, maize, barley, foxtail millet, wheat.

Geographic distribution: Reported on pearl millet only from the USA (Kansas).

Nomenclature discrepancies: None.

Seed transmission: Not known to be transmitted by seed.

Primary citation: Seifers et al. 1996.

Nematode Diseases

Also see table 6.

Burrowing Nematode

Radopholus similis (Cobb) Thorne

Symptoms: Symptoms on pearl millet are not described in the primary citation. General symptoms on maize include necrotic root lesions, root decay, and moderate stunting (Shurtleff 1980).

Pathogen and disease characteristics: Endoparasitic nematode. Not described in the primary citation; consultation of other references is advised.

Host range: "Banana" and "Citrus" races are defined based on host range. Host range is very wide and includes pearl millet. Also citrus, banana, avocado, sugarcane, rice, black pepper, tomato, hibiscus (Shurtleff 1980). See primary citation for extended list of hosts.

Geographic distribution: USA (Florida) (on citrus); Panama, Honduras, India.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citation: Koshy and Sosamma 1975.

Cyst Nematode

Heterodera gambiensis Merny & Netscher

Symptoms: Crop growth is variable and patchy.

Pathogen and disease characteristics: Females form egg sacs and cysts on roots. Brown cysts can be recovered from the soil.

Host range: Pearl millet, sorghum.

Geographic distribution: Gambia, Niger.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citation: Sharma 1990.

Table 6. Geographic distribution of plant parasitic nematodes associated with pearl millet*

Nematode species	Country
Aphelenchoides sp.	India
Aphelenchus sp.	India
Belonolaimus longicaudatus Rau	USA
Criconemella sp.	Senegal
Criconemoides sp.	USA
Ditylenchus sp.	India
Dolichorhynchus sp.	Senegal
Helicotylenchus dihystera (Cobb) Sher	Gambia, India, Senegal
Helicotylenchus indicus Siddiqui	India
Helicotylenchus sp.	India
Heterodera delvii Jairajpuri, Khan, Setty, & Govindu	India
Heterodera gambiensis Merny & Netscher	Gambia
Heterodera sorghi Jain, Sethi, Swarup, & Srivastava	India
Hirschmanniella mucronata Das	India
Hirschmanniella oryzae (van Breda de Haan) Luc & Goodey	India
Hoplolaimus indicus Sher	India
Hoplolaimus pararobustus (Sch. Stekh. & Teunissen) Sher	Senegal
Longidorus elongatus (de Man) Thorne & Swanger	India
Longidorus sp.	India, Senegal
Macroposthonia ornata (Raski) de Grisse & Loof	India
Meloidogyne graminicola Golden & Birchfield	India
Meloidogyne incognita (Kofoid & White) Chitwood	India, USA
Meloidogyne javanica (Treub) Chitwood	India, Malawi, USA, Zimbabwe
Meloidogyne sp.	Gambia, India, Senegal
Orientylus varus Jairajpuri & Siddiqi	India
Paratrichodorus christiei (Allen) Siddiqi	USA
Paratrichodorus minor (Colbran) Siddiqi	Senegal
Paratylenchus sp.	India, Senegal
Peltamigratus sp.	Gambia, Senegal

Dagger Nematode

Xiphinema americanum Cobb

Symptoms: Reduced vigor is implied in the primary citation. General symptoms on maize include reduction of feeder roots, root decay, moderate stunting, and chlorosis (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic nematode. Not described in the primary citation; consultation of other references is advised.

Host range: Pearl millet, sorghum-sudangrass hybrids. Also other grasses, legumes, sugarcane, cotton, pepper, tomato, citrus, pines, banana (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA. Consultation of other references is advised.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citation: Johnson and Burton 1973.

Table 6. Geographic distribution of plant parasitic nematodes associated with pearl millet*

Nematode species	Country
Pratylenchus brachyurus (Godfrey) Filipjev & Sch. Stekh.	USA
Pratylenchus mulchandi Nandakumar & Khera	India
Pratylenchus sefaensis Fortuner	Gambia, Senegal
Pratylenchus zeae Graham	India, USA
Pratylenchus sp.	India, Gambia, Senegal, USA
Radopholus similis (Cobb) Thorne	India
Rotylenchulus reniformis Lidford & Oliviera	India
Scutellonema sp.	India
Senegalonema sorghi Germani, Luc, & Baldwin	Senegal
Telotylenchus sp.	Gambia, Senegal
Trichodorus sp.	Gambia
Trichotylenchus sp.	Gambia, Senegal
Tylenchorhynchus brassicae Siddiqi	India
Tylenchorhynchus gladiolatus Fortuner & Amougou	Gambia, Senegal
Tylenchorhynchus indicus Siddiqi	India
Tylenchorhynchus mashoodi Siddiqi & Basir	India
Tylenchorhynchus phaseoli Sethi & Swarup	India
Tylenchorhynchus vulgaris Upadhyay	India
Tylenchorhynchus zeae Sethi & Swarup	India
Tylenchus sp.	Gambia, India
Xiphinema americanum Cobb.	USA
Xiphinema limpopoensis Heyns	South Africa
Xiphinema sp.	India, Gambia, Senegal

* This list is derived from Sharma (1985); used with permission of the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India. Appropriate citations are given by Sharma. Title of the original work suggests that while these nematodes are associated with pearl millet, pathogenicity may not have been confirmed.

Lance Nematode

Hoplolaimus indicus Sher

Symptoms: Symptoms on pearl millet are not described in the primary citation. General symptoms on maize include root lesions, moderate stunting, and chlorosis (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic, semiendoparasitic, and endoparasitic nematode that feeds mainly on cortical tissues. Prefers main roots and rootlets, not root hairs. Nematode feeds with anterior part of body embedded deep into cortical cells. Neither necrosis nor stunting of root has been observed.

Host range: Pearl millet. Also other grasses, legumes, sugarcane, cotton, pepper, tomato, citrus, pines, banana, others (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: Not defined in the primary citation. Identified on pearl millet in India.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citation: Nandakumar and Khera 1973.

Panagrolaimus Nematode

Panagrolaimus spp.

Symptoms: Nematode-infested seed are elongated, with a longitudinal fissure approximately two-thirds the length of one side. There is a small slit on the micropyle of the hilum region. Infested seed are shrivelled and dark gray or grayish black. They weigh less than healthy seed.

Pathogen and disease characteristics: Generally a common soil nematode. Seed can become infested when panicles are in contact with the soil.

Host range: Pearl millet, rice.

Geographic distribution: India.

Nomenclature discrepancies: None.

Seed transmission: Seeds are infested. Fumigation with methyl bromide (32 g/m^3) under vacuum for 4 hours does not kill the nematodes in dry seeds, but this treatment is effective on hydrated seeds. Infested seeds do not germinate.

Primary citation: Panchbhai et al. 1987.

Ring Nematode

Criconemella ornata (Raski) Luc & Raski

Symptoms: Reduced vigor is implied in the primary citation. General symptoms on maize include root lesions, root decay, mild stunting (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic nematode. Not defined in the primary citation; consultation of other references is advised.

Host range: Pearl millet, sorghum-sudangrass hybrids. Also other grasses, citrus, apples, peach, peanut, beans, soybeans, pines, others (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA. Consultation of other references is advised.

Nomenclature discrepancies: *Synonyms: Criconemoides ornatus* Raski.

Seed transmission: Not transmitted by seed.

Primary citation: Johnson and Burton 1977.

Root-Knot Nematode

Meloidogyne incognita (Kofoid & White) Chitwood
Meloidogyne javonica (Treub.) Chitwood
Meloidogyne arenaria (Neal) Chitwood

Symptoms: Plants can exhibit chlorosis and become stunted. Maturity is delayed. Galls develop on roots.

Pathogen and disease characteristics: Endoparasitic nematode. Not described in the primary citations; consultation of other references is advised.

Host range: Pearl millet, sorghum-sudangrass hybrids. Also legumes, cotton, tobacco, tomato, vegetables, strawberry, peach, ornamentals, others (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA, India. Consult other references for additional information.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citations: Johnson et al. 1977, Vaishnav and Sethi 1978.

Root-Lesion Nematode

Pratylenchus mulchandi Nandakumar & Khera
Pratylenchus brachyurus (Godfrey) Filipjev & Sch. Stekh.
Pratylenchus zeae Graham

Symptoms: Symptoms on pearl millet are not described in the primary citations. Reduced vigor is implied. General symptoms on maize include poor root growth, necrotic root lesions, root decay, moderate stunting (Shurtleff 1980).

Pathogen and disease characteristics: Endoparasitic nematode. Feeds mainly on rootlets

and roots and occasionally on root hairs, rarely on tips of root cap cell masses. Its head region is embedded deep into the plant's cortex while it feeds on the main roots. Superficial feeding, confined to epidermal cells, occurs occasionally. Prolonged feeding at the same site did not cause any necrosis on pearl millet roots.

Host range: Pearl millet, sorghum, sudangrass. Also other grasses and cereals, sugarcane, legumes, tobacco, tomato, potato, strawberry, tree fruits, pines (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA, India.

Nomenclature discrepancies: *Alternative common name:* Lesion nematode.

Seed transmission: Not transmitted by seed.

Primary citations: Johnson and Burton 1973, Nandakumar and Khera 1973.

Sting Nematode

Belonolaimus longicaudatus Rau

Symptoms: Reduced vigor is implied in the primary citation. General symptoms on maize include root lesions, stubby roots, coarse roots, severe stunting, and chlorosis (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic nematode. Consultation of other references is advised.

Host range: Pearl millet, sorghum, sudangrass. Also other cereals, grasses, cotton, potato, cabbage, legumes, strawberry, celery, pines, others (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA. Consultation of other references is advised.

Nomenclature discrepancies: None.

Seed transmission: Not transmitted by seed.

Primary citation: Johnson and Burton 1973.

Stubby-Root Nematode

Paratrichodorus minor (Colbran) Siddiqi

Symptoms: Symptoms on pearl millet are not described in the primary citation. Reduced vigor is implied. General symptoms on maize include stubby lateral roots, coarse roots, excessive upper roots, severe stunting, and chlorosis (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic nematode. Not described in the primary citation; consultation of other references is advised.

Host range: Pearl millet, sorghum-sudangrass hybrids. Also other grasses, legumes, cotton, potato, tomato, cabbage, beet, citrus, ornamentals, others (Shurtleff 1980). Consult other references for additional hosts.

Geographic distribution: USA. Consultation of other references is advised.

Nomenclature discrepancies: *Synonym: Trichodorus christiei* Allen.

Seed transmission: Not transmitted by seed.

Primary citation: Johnson et al. 1977.

Stunt Nematode

Tylenchorhynchus vulgaris Upadhyay
Tylenchorhynchus phaseoli Sethi & Swarup
Tylenchorhynchus zeae Sethi & Swarup

Symptoms: Stunting in shoots and roots of pearl millet. General symptoms on maize include poor root growth, moderate stunting, chlorosis (Shurtleff 1980).

Pathogen and disease characteristics: Ectoparasitic nematode. See primary citation for species descriptions.

Host range: Wide. Includes grasses, cereals, tobacco, cotton, legumes, pepper, tomato, others (Shurtleff 1980).

Geographic distribution: Not defined in primary citation. Isolated from root zone of pearl millet in India.

Nomenclature discrepancies: *Additional species*

isolated from pearl millet root zone:
Tylenchorhynchus brassicae Siddiqi, *T. mashoodi* Siddiqi & Basir.

Seed transmission: Not transmitted by seed.

Primary citation: Sethi and Swarup 1968.

Parasitic Flowering Plants

Witchweed

Striga hermonthica Benth.
Striga asiatica (L.) Kuntze

Symptoms: Severe attack produces leaf wilting and chlorosis. Infected plants may be stunted and die before seed set.

Pathogen and disease characteristics: *Striga* seeds are stimulated to germinate by root exudates of the host. Plants emerge close to host plant 1 to 2 months after crop is planted, flower 3 to 4 weeks after emergence, and produce mature seed a month later. The species are similar in appearance, with square stems, small, bright green elongated leaves, and red to pink flowers. Seeds are minute (less than 0.25 mm long) and borne in pods or capsules.

Host range: Pearl millet, maize, sorghum, sugarcane, rice, sudangrass, wheat, oats, barley.

Geographic distribution: USA (North and South Carolina), Africa, Australia, India, Indonesia, Southeast Asia.

Nomenclature discrepancies: None.

Seed transmission: Not seed transmitted.

Primary citations: Williams et al. 1978, Shurtleff 1980.

Questionable or Poorly Described Diseases of Pearl Millet Reported in the Literature

Bacterial Leaf Spot/Bacterial Leaf Blotch

The bacteria *Xanthomonas penniseti* (Rajagopalan and Rangaswami 1958) and *Xanthomonas annamalaiensis* (Rangaswami et al. 1961a), isolated from diseased pearl millet in India, and *Xanthomonas rubrisorghi*, isolated from sorghum and pathogenic to pearl millet (Rangaswami et al. 1961b), have been determined to be *Erwinia herbicola* (Qhobela and Claflin 1988). These bacteria are gram negative, noncapsulated, non-spore-forming, short rods with a single monotrichous polar flagellum. Colonies are dull shiny yellow on nutrient agar, and no soluble pigment is formed. Because standardized inoculation procedures were not used in prior assays, the assumption that *Erwinia herbicola* is pathogenic to pearl millet should be re-examined (L.E. Claflin, personal communication, 1995). A later report suggests that *Pantoea agglomerans* (=*Erwinia herbicola*) is pathogenic to pearl millet in Zimbabwe (Frederickson et al. 1997).

Yellow Leaf Blotch

Yellow leaf blotch, caused by a bacterium tentatively identified as a *Pseudomonas* sp., was reported on pearl millet, maize, sorghum, johnsongrass, wheat, and unidentified grasses in Cameroon, Ghana, Niger, Nigeria, and Senegal (Zummo 1976). Lesions can develop in the seedling stage and are cream yellow to light beige and distinct, with a tendency for streaks to follow the veins. Lesions in pearl millet usually form at leaf tips. Young infected plants can be stunted.

Some differences in symptoms exist between this and other diseases caused by *Pseudomonas* spp., suggesting it may be a different pathogen. The lack of bacterial exudate associated with the lesions is generally not characteristic of bacterial diseases. In addition, the genus of the bacterium was not positively identified. Additional studies on the etiology of this disease are required.

Alternaria Leaf Spot

Alternaria alternata (Fr.) Keissler was isolated in India from pearl millet samples (either leaf spots or head mold, not clearly stated) and inoculated back onto pearl millet. Scattered oval to irregularly shaped lesions developed on the leaves. Lesions were copper red with black in the center and varied from 5 to 20 mm

in diameter. This disease has been reported once (Gaikwad and Rane 1977) and may be an artifact of controlled inoculations.

Charcoal Rot

Charcoal rot, caused by *Macrophomina phaseolina,* has been reported on "millet" (Botswana 1987). This report is subject to question, since the "millet" referred to in the report was not specifically identified as pearl millet, and several pathogens of pearl millet (for example, *Puccinia penniseti, Tolyposporium penicillariae,* and *Claviceps fusiformis*) were identified as causal agents of diseases of maize. Further verification will be useful before confirming that charcoal rot is a disease of pearl millet in Botswana.

A disease called dry stalk rot of pearl millet was described from India and reported to be caused by *Macrophomina phaseolina* (Singh et al. 1997). The disease caused blackening or browning of the stem usually above the first node and extending beyond the second or third node. Tillering was reduced, and plants often died before flowering. Pycnidia developed on infected internodes. Pith tissue was disintegrated, and vascular bundles were free. Infected plants sometimes lodged. Inoculations were performed to confirm pathogenicity.

Konde et al. (1980) has reported isolation of *Rhizoctonia bataticola* (=*Sclerotium bataticola* Taub [teleomorph: *Macrophomina phaseolina* (Tassi) G. Goid.]) from seed in India.

Cochliobolus Leaf Spot

Cochliobolus bicolor was isolated from small, dull brown, round to irregular spots on pearl millet foliage in India in 1967. After controlled inoculations, small water-soaked lesions developed within 48 hours of incubation. During the subsequent 48 hours, lesions turned from light yellowish green through yellowish grey, light grey, and finally dark grey as a result of profuse sporulation of the pathogen. Lesions eventually covered large areas of the leaf and ultimately caused drying of the entire leaf. The pathogen was identified as the conidial stage of *Cochliobolus bicolor* (anamorph: *Bipolaris bicolor*) (Misra and Singh 1974). Additional occurrences of infection of pearl millet have not been reported, however. See table 2 for other *Bipolaris* species reported to be pathogenic to *Pennisetum.*

Ephelis Panicle Infection

Ephelis oryzae was identified on a single diseased panicle of pearl millet grown next to foxtail millet [*Setaria italica* (L.) Beauv.] in India in 1975. Florets in the lower half of the affected panicle were greyish and glued and pressed toward the rachis. Spores were acicular hyaline and measured 15–24 × 1.4–1.8 μm with an average length of 19.26 μm, which is very close to the spore size of *E. oryzae* on *S. italica.* This disease was an atypical occurrence, which does not appear to have been observed again. *E. oryzae* has also been reported on *Pennisetum hohenackeri* and *P. alopecuroides* (Reddy and Lucy Channamma 1976). *Balansia* is the teleomorph of *Ephelis. Balansia claviceps* Speg. has been cited as a pathogen of pearl millet in Senegal by Ramakrishnan (1971); however, the source citation referred to in that publication is incorrect and thus is unavailable for examination. Other reported hosts include *Echinochloa crus-galli, Setaria italica, Isachne elegans,* and *Eragrostis tenuifolia* (Venkatakrishniah 1952).

Kikuyu Yellows

A phycomycete resembling a species of *Achlya* was isolated from leaves of kikuyugrass *(Pennisetum clandestinum)* in Australia. Leaves become uniformly yellow with brown flecking. Roots become yellowish brown and rotted. No information is available concerning its pathogenicity to pearl millet or other *Pennisetum* species (Wong 1975).

Leptosphaerulina Leaf Spot

Leptosphaerulina trifolii (Rost) Petr. was isolated in India from pearl millet samples (either leaf spots or head molds—the report was not clear) and inoculated back onto pearl millet. Initial infection of leaves developed as small, light

brown spots that later turned papery, with perithecia in the center. Ascospores have muriform septation. This disease was reported once (Gaikwad and Rane 1977) and may be an artifact of controlled inoculations.

Pestalotia Leaf Spot

Pestalotia disseminata Thuman was isolated in India from pearl millet samples (either leaf spots or head molds, not clearly stated) and inoculated back onto pearl millet. Initial infection of leaves developed as minute brown spots that subsequently developed into oval to elliptical brown lesions that have dark copper red margins surrounded by a faint yellow halo and vary from 5 to 20 mm in diameter. This disease was reported once (Gaikwad and Rane 1977) and may be an artifact of controlled inoculations.

Smut

Information on smut of pearl millet is quite confused in the literature. Several apparently unique species have been reported or implicated in the cause of smut diseases of pearl millet. For example, Rachie and Majmudar (1980) wrote:

> "The fungus *Tolyposporium senegalense* Speng. [sic], *T. bullatum* Schroet., and *Sorosporium bullatum* Schroet. was first reported from Africa (Corbetta 1954); but Mundkur (1940) reported its occurrence in the region of Poona, India. Hirschorn (1941) suggested the name *T. bullatum,* as *T. senegalense* was only a synonym of the same species. It also attacks *Echinochloa crusgalli* in Germany."

Corbetta's (1954) paper is in Italian, and from what I can understand, he is attempting to clarify the nomenclature of the smut pathogen of *Panicum crus-galli* and *P. erectum.* I believe that his final conclusion is that *Tolyposporium bullatum, Sphacelotheca destruens,* and *Sorosporium panici-miliacei* should be named *Sorosporium bullatum.* Pearl millet, or an associated smut pathogen of pearl millet, is not mentioned.

The argument for synonymy of *Tolyposporium senegalense* and *T. bullatum* was made by Hirschorn (1941). The paper is written in Portuguese (?) and I believe that Hirschorn promoted lumping these two species based on morphologic similarities. Cross-inoculation studies were unsuccessful, but he attributed this to physiological differences. Although similar morphology may be adequate to include the fungi in the same genus, sporidial cross-compatibility should probably be examined before concluding that the fungi are identical, particularly since the two fungi are reproductively isolated from each other because of host specificity.

Vanky (1977) split several species out from *Tolyposporium* into a new genus, *Moesziomyces.* After examining the type specimens, it was concluded that *T. penicillariae* and *T. senegalense* were the same species, *M. penicillariae,* which differed from *M. bullatus.* Mordue (1995) reinforced the observation that *M. penicillariae* and *M. bullatus* are morphologically similar, but there appear to be biological differences in host specificity and possibly in germination.

Mundkur (1940) described a fungus named *Ustilago penniseti.* This specimen was described from infection on *Pennisetum fasciculatum* and has not been demonstrated to be pathogenic to pearl millet, *Pennisetum glaucum.* Subsequent observations of the disease have not been reported.

Likewise, Mundkur (1939) stated that he considers *Tilletia pennisetina* and *Neovossia barclayana* as synonyms. These type specimens were collected from *Pennisetum alopecuroides* and *P. orientale,* respectively, and thus cannot be considered to be pathogenic to pearl millet without completing Koch's postulates. No subsequent observations of the disease have been reported.

Mundkur's (1939) original report of *Tilletia ajrekari* as a pathogen of pearl millet should also be examined closely. In the description, he stated that a single infected ovary was found in greenhouse-grown plants. Examination of other plants in the greenhouse and field failed

to identify any other similar sori. In this case, a new species was described based on spore characteristics of a single infected ovary. In a later publication (Mundkur and Thirumalachar 1952) the description is the same; however, here it is implied that several ovaries were infected. Because of the nonsystemic infection and other characteristics of the spores, he stated that it may be a species of *Neovossia*. "This can be definitely decided only after the germination of the spores has been obtained." In this reference he also states "germination unknown" regarding the spores. This leads me to believe that no inoculations were ever performed. This possibility, plus the discrepancy between a single infected sorus as described in the 1939 paper and several sori in the 1952 reference leads me to question whether this work is valid or can be reproduced.

Sooty Mold

In India, a black, fluffy fungal growth was observed on the auricles of older leaves on either side of the leaf sheath. The fungus was identified as *Microxyphiella hibiscifolia* Bat., Nasc., & Cif. Elongate to linear pycnidia, black to dark olive in color, attach superficially to epidermal cells. Although described as a pathogen (Singh and Grover 1968), sooty mold fungi generally colonize insect honeydew or plant exhudates and are not considered to be plant pathogens.

Stalk Rot

Information concerning stalk rot of pearl millet is currently limited. *Fusarium poae* (Peck) Wr. was isolated from diseased stalks and inflorescences in India (Ramakrishnan and Subramanian 1952). Inoculations to verify pathogenicity were not performed.

Bipolaris panici-miliacei (Nisikado) Shoem was isolated from a diseased pearl millet stalk in India (Navi et al. 1997). Inoculations to verify pathogenicity were not performed.

Many fungi can be isolated from pearl millet stalks. Some of the more common pathogens from diseased stalks in the southeastern United States include *Fusarium semitectum, F. moniliforme, F. graminearum, Alternaria* spp., and *Nigrospora* spp. (Wilson et al. 1999). Inoculations to verify pathogenicity were not performed. Although many fungi can be isolated from diseased stalks, lodging has only been reported in association with severe rust infection (Wilson et al. 1996a).

Fungicide Treatments for Pearl Millet Seed

The following treatments for pearl millet seed are used at ICRISAT* Center (Ahmed and Reddy 1993).

Recommended seed treatment to prevent transmission of downy mildew

1. Soak seed for 10 min with 0.1-percent $HgCl_2$ followed by several rinses in running water.
2. Transfer seed to hot water bath at 55 °C for 12 min.
3. Transfer seed to water at room temperature for a few minutes, then transfer to incubator at 35 °C for 12 hr and then at 40 °C for 1 hr.
4. Immerse seed in suspension of 2 g metalaxyl in 800 ml of 1-percent aqueous methyl cellulose for 5 to 6 hr (sufficient for 1 kg dry pearl millet seed).
5. Allow seed to dry. Treated seed can be sown immediately or up to 4 months after treatment.

Recommended seed treatment for other pathogens

2.5 g benomyl + thiram (1:1) per kg of seed.

*International Crops Research Institute for the Semi-Arid Tropics. Information used with permission of ICRISAT.

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